Point-of-use xenon purity provision for Ion Propulsion System on Deep Space One

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ABSTRACT

The Ion Propulsion System, which will fly on the New Millennium Deep Space One spacecraft, utilizes ultra-pure ($\geq$ 99.999% pure) xenon, which is stored in a super-critical state. High purity xenon is required to prevent poisoning of the impregnated tungsten emitters within the cathodes, and it is stored supercritically to minimize the required propellant tank mass and volume. Both of these requirements present unique challenges in handling, testing, and loading this propulsion system.

Several methods for achieving xenon purity within the flight propulsion system and all test and loading ground support equipment used to deliver xenon to the feed system were developed and qualified at JPL during the DS-1 integration and test activities leading to launch. Methods for accounting for xenon supercriticality in loading were also developed. Pre-flight sampling of the xenon within the propulsion system showed that contaminant concentrations of 0.01 ppm O_2, 0.013 ppm H_2O, < 0.1 ppm CO_2, < 0.1 ppm CF_4, < 0.1 ppm Total HydroCarbons and < 5.0 ppm He were achieved. A loading accuracy of +/- 0.5 kg was also achieved.

Some lines within the propulsion system, and even the cathodes themselves, are exposed to the atmosphere subsequent to system purification but prior to launch. Thus, post-launch activities to minimize cathode risk, such as exposing lines previously exposed to atmospheric air to direct sunlight for 24 hours while purging them with xenon from the propellant tank, are required prior to turning on the ion thruster. The cathodes themselves are heated to remove any contaminants that may be attached to their inner surfaces, in a process known as cathode conditioning.

Based on the processes used, it is projected that the flight cathodes will be exposed to less than 0.02 ppm of water throughout the DS-1 mission.

In this paper, detailed discussions backed up with appropriate analyses, are presented on the techniques used to purify xenon systems, the processes for system xenon loading (with load uncertainty calculations) and the analysis used to determine the amount of outgassing which occurs within the systems.